Atomic Layer Deposition, Nanoparticles, and Photochemistry

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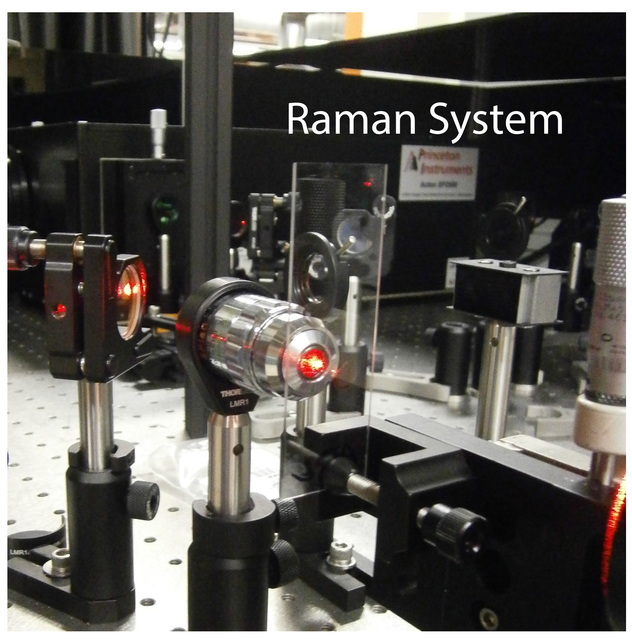
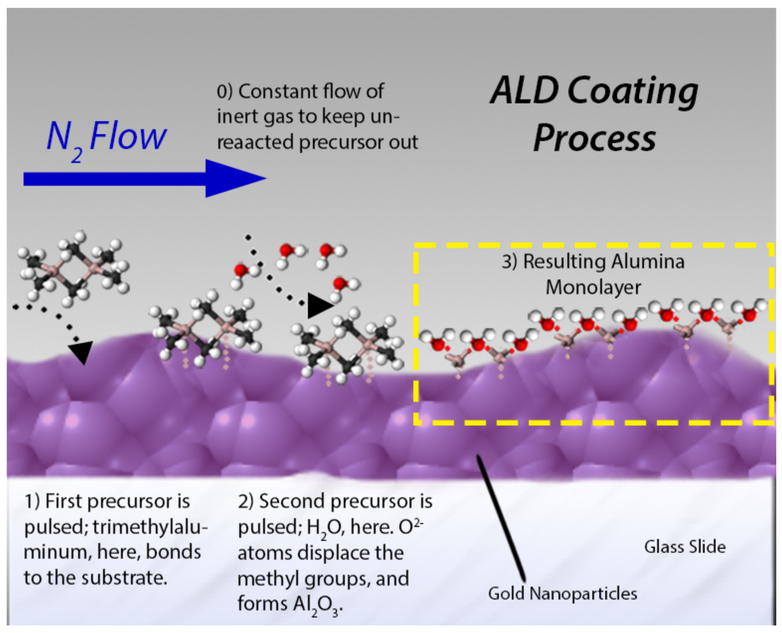
Introduction

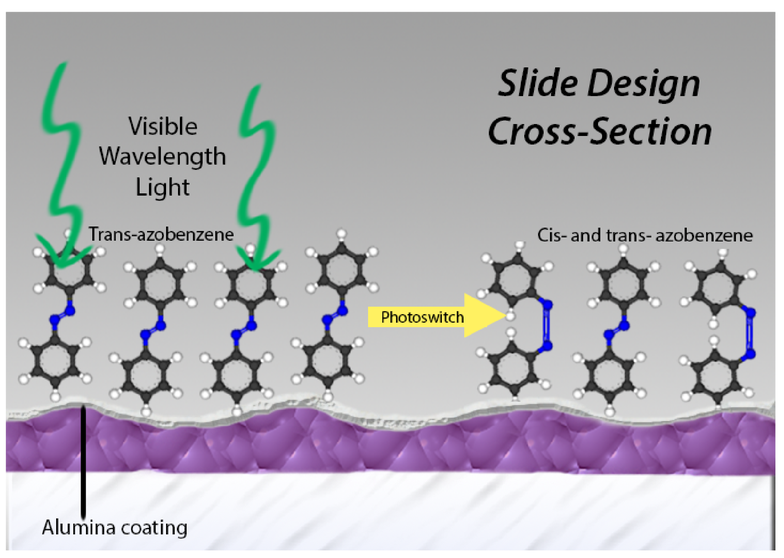
Plasmonic materials have been employed over many years of research to enhance electromagnetic waves. Essentially, such a material's electron cloud couples with the EM waves disturbing it, creating a "hotspot." I have used gold nanoparticles (AuNPs), which enhance the visible wavelengths of light in particular, to boost both the surface-enhanced Raman spectroscopy (SERS) used to evaluate my design and the core photochemical reaction of azobenzene photoisomerization.



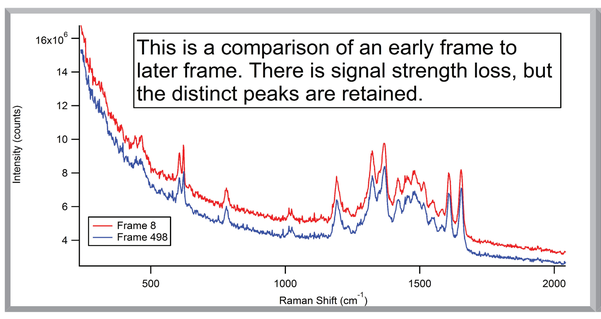
Making the slides

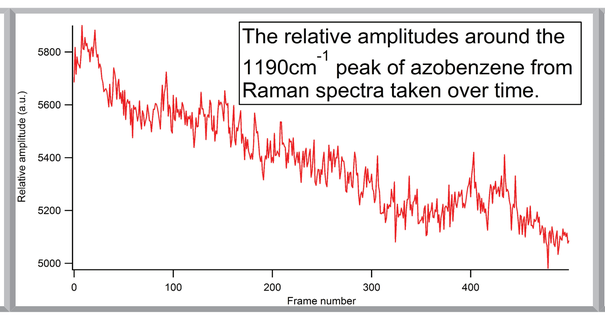
The first step was depositing the AuNPs onto the slides; I simply centrifuged the lab's colloid, and then I would drop small volumes of NPs on the slide. The second step was to bring the slides to the University's Nano Center (MNC), where I used an Atomic-Layer Deposition machine to repeatedly coat the slides in alumina (Al_2O_3) which served as a non-reactive spacer layer between the molecule of focus and the gold. The third and final step was to deposit the molecules onto the slide and use the lab's He-Ne laser table to find SERS signals as I try to photoswitch the molecule.

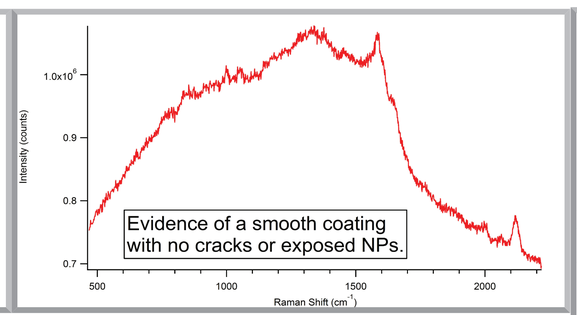


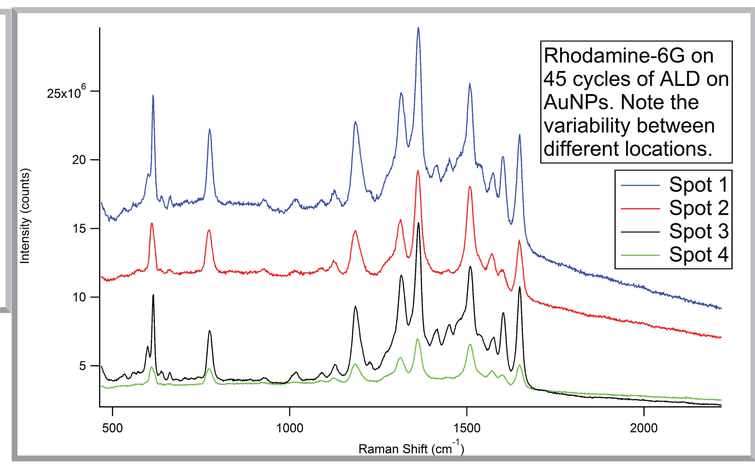


Characterization







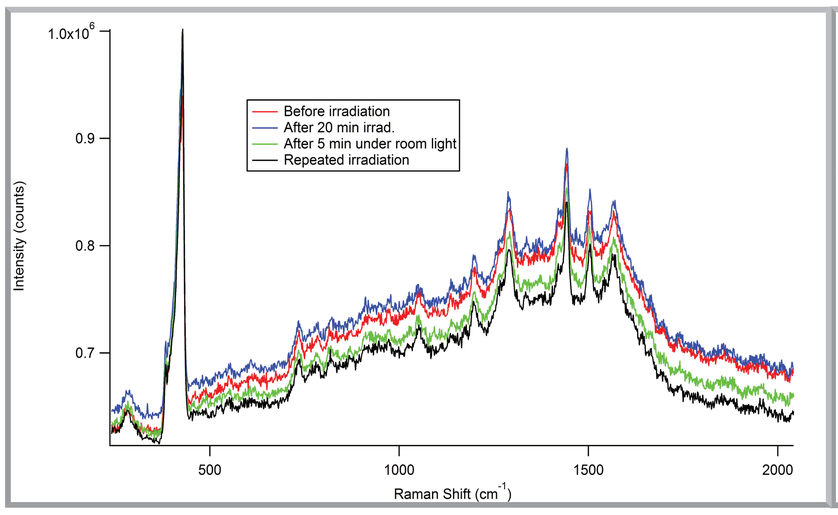


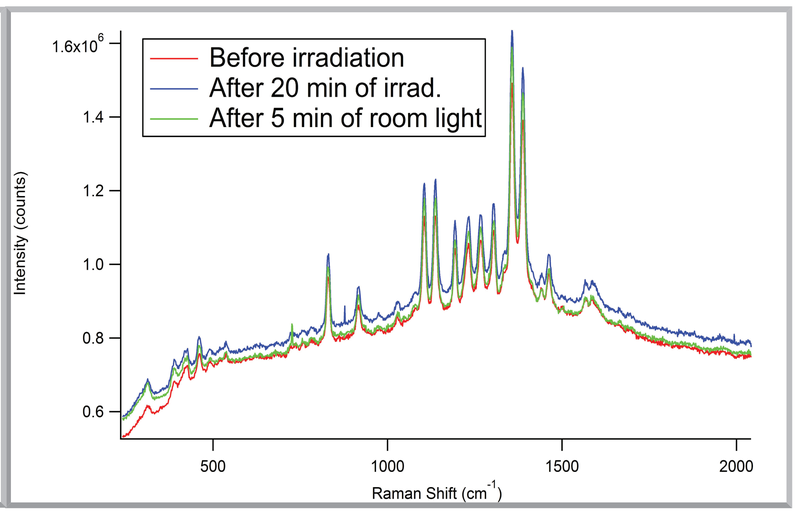
The data here show that the intensity of SERS varies a lot from particle to particle, but this design does indeed generate SERS (right). The laser used for the majority of spectra does not greatly damage the specimen (left graphs). After depositing a molecule called pyridine, having a simple Raman peak at 1000cm^{-1}, onto a test slide and then taking a spectrum, I found that the ALD coating does not leave the AuNPs exposed (center-right).

Photoswitching and Future Work

The left graph displays typical azobenzene spectra. On the right are spectra of Methyl Red, a molecule that offers better SERS signal but is harder to isomerize. Work was done with both molecules over the course of my project because of those differences. To photoswitch either molecule, I irradiated the sample with green LEDs. The changes in molecular vibrations from successful photoisomerization would be reflected in peak changes, both in Raman Shift as well as intensity.

Further optimization is in progress, but the idea of photoswitching with plasmons is still viable and compelling. If this process could be perfected, flash memory or similar bit operations we use now could be replaced by a greener, organic molecule-based option.





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